An Alternative Feed Design for the MRO Antenna

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Summary: NASA's Mars Reconnaissance Orbiter (MRO) [1], scheduled for launch in 2005, will study the history of water on Mars. The current feed design for the 3-meter reflector antenna uses a dielectrically supported disk-on-rod Ka-band (32 GHz) feed in the center of an X-band (7.2, 8.4 GHz) corrugated horn. As a potential backup design in case of problems, an alternate feed design for the MRO antenna that does not use any dielectric materials or a disc-on-rod was developed. The design uses a Ka-band Potter Horn in the center of the current X-band MRO corrugated horn. Using the same High-gain reflector assembly, the new feed provides virtually the same X-band gain (within 0.1 db) and more than 1 dB improvement at Ka-band.

Design Technique: The basic concept is to use a high-frequency (Ka-band) horn in the center of the low frequency (X-band) horn. The outer horn is thus fed by a coax mode. The parameters to be selected are then:

1) The outer horn design
2) The inner horn design and diameter
3) The location of the aperture of the inner horn
4) The return loss matching technique

Since the existing disc-on-rod design already has an X-band outer horn that is well matched to the displaced axis reflector system, the most effective use of design time would be to use the current outer horn geometry. Consequently, the outer horn geometry, including the inner feed diameter was selected as the starting point of the design. The two most significant parameters to be selected are then the Ka-band horn diameter and location of the Ka-band aperture. It was ascertained that, if the aperture was located at the beginning of the first corrugation, the X-band patterns of the composite feed system did not change significantly with Ka-band feed diameter. However, the larger the Ka-band feed diameter, the greater was the X-band feed mismatch. If the aperture was placed forward of the first corrugation, the X-band transmit pattern was degraded. The question was then whether or not a Ka-band horn placed at the beginning of the first corrugation would be adequate for Ka-band considering the phase center and gain of the composite system. A series of horns with varying Ka-band designs and feed diameters were examined for phase center location and Ka-band gain. It was determined that a 5 degree flair Potter horn with a 17.8 mm (0.7 inch) aperture diameter would meet all the specifications of the design. A simple two iris design was used for matching the X-band frequencies and produced a greater than -28 dB return loss over the receive band and better than a -19 dB return loss over the transmit band. If required, a more sophisticated matching technique could be used to widen the frequency bandwidths.

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Performance: The outline of the composite feed horn design is shown in Figure 1. It consists of a 17.8 mm tube up the center of the MRO X-band horn terminating at the beginning of the first corrugation. Contained inside the tube is a 5 degree flair Potter horn with a 10.45mm (0.411 inch) input diameter. The E- and H-plane X-band feed pattern at 8.439 GHz is shown in Figures 2 and the E- and H-plane feed patterns of the Ka-band horn in Figure 3. Placing the aperture of the feed 130 mm in front of the dual reflector focal point optimizes the Ka-band gain. Relative to the maximum gain possible, the X-band transmit gain is only lower by 0.05 dB and the X-band receive gain lower by 0.03 dB. The X-band return loss is shown in Figure 4. The Ka-band return loss in better than -35dB over the entire band. The overall performance is summarized in Table 1 comparing the design to the specification as well as to the performance of the disc-on-rod design.

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Table 1 High Gain Antenna Loss Budget

Loss	7183 MHz	8439 MHz	32223 MHz
Ideal Directivity	47.069	48.469	60.106
Aperture Efficiency Loss	-1.134	-1.072	-1.419
Surface Tolerance Loss (From Review package)	-0.015	-0.020	-0.296
Surface Reflectivity Loss	-0.087	-0.087	-0.355
Assembly Return Loss	-0.014	-0.069	-0.004
Feed Network waveguide insertion loss	-0.050	-0.050	-0.200
Subreflector misalignment loss	-0.029	-0.029	-0.093
Subreflector Strut Blockage Loss	-0.482	-0.482	-0.400
Radome Loss	-0.050	-0.050	-0.100
Gain Requirement	45.200	46.600	56.100
Total Gain – Best Estimate /Efficiency	45.208 / 65.1%	46.610 / 65.2 %	57.239 / 51.7 %
DOR Estimate	45.288	46.561	55.903

References:

[1] Mars Reconnaissance Orbiter, http://marsprogram.jpl.nasa.gov/mro/

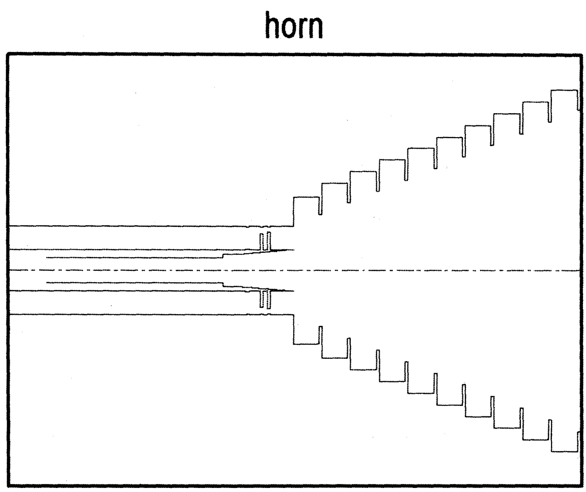

Figure 1 Feed Outline

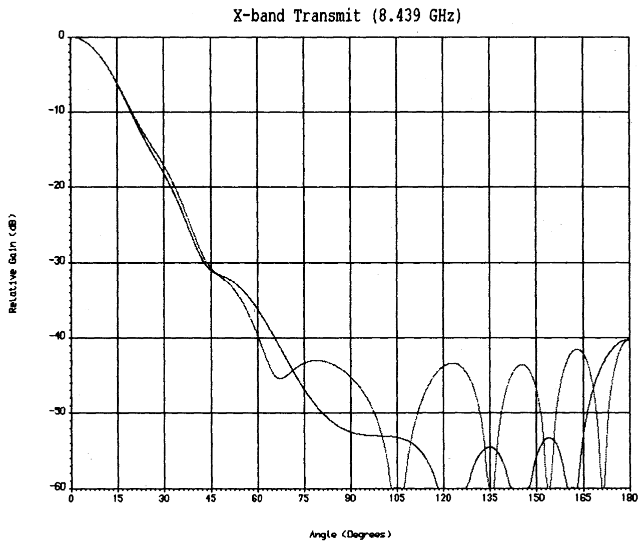

Figure 2. E- and H-plane Feed Patterns at 8.439 GHz

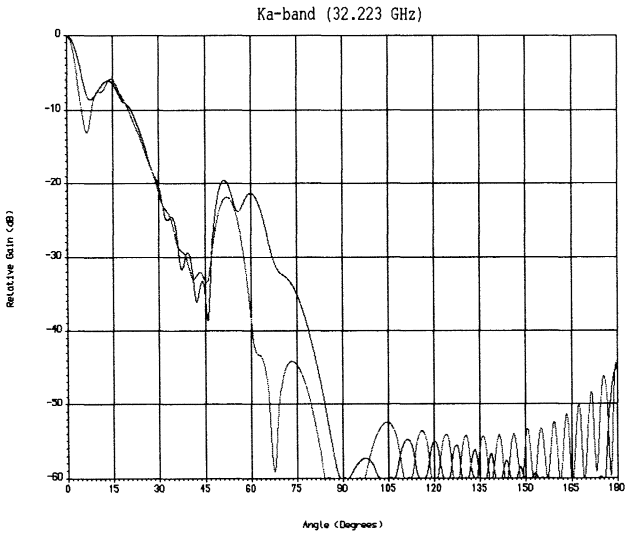

Figure 3. E- and H-plane Feed Patterns at 32.223 GHz

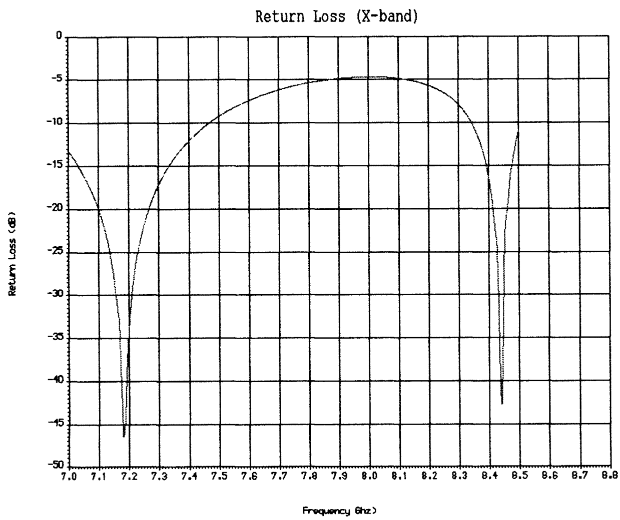

Figure 4. X-band Return Loss